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Abstract

Background: Many studies have used the concept of 'walkability' to assess how conducive a neighbourhood is to physical activity, especially active travel. Studies in the United States and Australia have traditionally used a road-based network system of intersection density to derive a walkability index. However, other studies suggest that analyses based on footpath networks may provide a more robust basis for assessing the walkability of built environments in the European context as they better capture alternative opportunities for physical activity such as parks and greenways. To date, no studies have examined whether a road- or footpath-based network is more closely related to actual physical activity behaviour. Therefore, the aims of this paper were to examine associations between active travel and walkability indices based on both road- and footpath-based intersection density and to establish which measure provided the best fit to the data. Methods: Cross-sectional survey and geographical information system (GIS) data were collected from February 2010-January 2011. A series of crude and fully adjusted zero-inflated negative binomial regression analyses examined associations between road- and footpath-based walkability and the average minutes per week of active travel. Results: Model fit indices suggested that the models using road-based walkability provided a marginally better fit. However, regression results indicated similar findings with respect to the effect of road- and footpath-based walkability on active travel. Conclusion: Results suggest that footpath-based indices of walkability are comparable to road-based indices in their associations with active travel and are an alternative model, particularly for assessing environmental change in non-road-based built environment interventions.

Keywords

walkability index; footpaths; built environment; travel-related physical activity; active travel

Highlights

- First study using both road- and footpath-based walkability to examine active travel.
- Results indicated that the two measures performed comparably.
- Footpath-based walkability is acceptable alternative to road-based walkability.
- Method has key implications for non-road-based environmental change interventions.

1.0 Introduction

Recent studies have suggested that certain aspects of the built environment can influence levels of physical activity (Sallis et al., 2012). In particular, the concept of 'walkability' has been used as a means of assessing how conducive a neighbourhood is to walking, and more generally, physical activity. Walkability has been defined as "the extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort and offering visual interest in journeys throughout the network" (Southworth, 2005, p. 248). Attempts have been made to capture those built environment characteristics that are associated with this in the form of a single walkability index. This single indicator allows for the capture of a range of built environment attributes known to support walking behaviour, their variation across space, and links with other factors, such as physical activity, for the purposes of research or planning. The most widely used walkability index (see Method section for how it is calculated) (Adams et al., 2014; Frank et al., 2010; Leslie et al., 2007) combines the following four components:

1. Residential density, residents per km (Adams et al., 2014);
2. Retail floor area ratio, representing the retail building floor area divided by the retail land site area;
3. Land use mix, based on five categories (residential, retail, entertainment, office, and institutional) and calculated using an entropy equation whose normalised outcome was between 0 (single use) and 1 (complete even distribution of land use categories); and
4. Street connectivity, calculated using intersection density based on road centre lines calculated as the ratio between the number of road intersections of three or more legs and the land area.

Intersection density (ID) appears to have the greatest influence over active travel (Leslie et al., 2007; Ellis et al., 2016).

The connectivity of any built environment relates to how easy it is to get from point A to point B, and is largely derived from the morphological characteristics of the urban form, including block size and density of streets and paths. It has been suggested that the more connected an urban area, the more conducive it will be to physical activity, independent of other variables (Berrigan et al., 2010). As a result, improving connectivity has become a focus for active travel interventions (Goodman et al., 2014), and it should, therefore, be possible to associate improvement in connectivity with active travel outcomes. Connectivity measures included in the index have conventionally been derived from the networks formed by the road centre lines and as such, are essentially only *proxies* for connectivity of pedestrian infrastructure. Furthermore, it has been noted that there are a series of common errors in road networks (Frizelle et al., 2009), examples of which are noted in Figure 1. There is, however, almost universal availability of road network data and they are utilised on the assumption that pedestrians primarily use footpaths that run parallel to roads, thus neglecting the influence of non-motorised networks such as footbridges, paths through parks, etc. Indeed, this could mean that road-based walkability indices are not useful at capturing change in non-road based opportunities for physical activity, such as parks, footbridges, greenways, and cycle lanes. Recent guidelines on the environment and physical activity from the National Institute for Health and Care Excellence (NICE, 2008) in the UK have identified the need for the creation of appropriate methodologies to measure how environmental policies and projects can help increase people's physical activity levels. Therefore, the creation of indices that better capture the types of environmental features targeted in these interventions are required, demonstrating the need to assess a footpath-based walkability index. Given the need for built environment interventions (Hunter et al., 2015), such a model would have important implications for assessing non-road-based environmental change interventions.

Some studies (Chin et al., 2008; Ellis et al., 2016; Tal and Handy, 2012) have suggested that a network that reflects *all* potential route choices for pedestrians has a much greater resolution and potentially provides a better representation of connectivity, which intuitively should offer a more accurate basis for determining the walkability of built environments than those based on road centre lines alone. One study (Ellis et al., 2016) has tested how different measures of connectivity should be used in footpath-based assessments of walkability and has concluded that intersection density is as applicable for measuring connectivity in footpath networks as it is for road networks.

To the best of our knowledge, Ellis et al. (2016) remains the only study to date that has used both non-motorised networks and actual observed physical activity data to empirically test these relationships. However, there are still no studies to date that have empirically compared road- and footpath-based walkability indices and their associations with physical activity. Therefore, the key aim of this paper was to examine associations between active travel and walkability indices based on both road- and footpath-based intersection density and to establish which measure provides the best fit to the data.

2.0 Methods

2.1 Respondents

A cross-sectional, interviewer-administered self-report survey was conducted and geographical data collected during the period February 2010 to January 2011 as part of a natural experiment examining the health and health behaviours of a sample population experiencing a programme of urban regeneration in East Belfast, Northern Ireland (Tully et al., 2013). A representative stratified random sampling of 1209 households (representative of the Northern Ireland population based on age, gender, and 2001 Census deprivation indicators), resulted in one adult in the household (aged 16 and over) being randomly selected and surveyed (see Tully et al., 2013, for further details of sampling and recruitment). The survey will be repeated in 2017 following the construction of 9km of new greenway infrastructure that includes footbridges, pedestrian paths, and road crossings.

2.2 Measurements

2.2.1 Dependent variable – active travel

Respondents completed the Global Physical Activity Questionnaire (GPAQ; Bull, Maslin, and Armstrong, 2009). Minutes of active travel per week were calculated using the validated method whereby average number of days per week and minutes per day spent in some mode of active travel (e.g., walking or cycling) were aggregated to derive a continuous summary variable (Bull et al., 2009) that was used for the inferential statistical analysis (see section *2.4 Analytic strategy*) (missing data for 1 respondent [<0.1%]). For the purposes of descriptive statistics (see Table 1), and to establish the extent of zero counts in active travel, the GPAQ continuous summary score was dichotomised to derive a binary ‘active travel’ variable, with scores of ‘0’ coded as ‘none’ and scores greater than ‘0’ coded as ‘some’.

2.2.2 Primary covariate – walkability indices

Continuous measures of road- and footpath-based walkability indices were derived using standardised measures of residential density, retail floor area ratio, land use mix, and intersection density, with the latter being based on both road- and footpath-based networks respectively. The index was derived using the formula validated in previous studies (Frank et al., 2010; Leslie et al., 2007): Walkability = [(2x z-scores of intersection density) + (z-scores of net residential density) + (z-scores of retail floor area ratio) + (z-scores of land use mix). These were calculated for two areas around each respondent's residential address (in Excel), using both 5- (500 metre) and 10-minute (1000 metre) network defined buffer zones.

In the case of the footpath-based network used here, intersection points were inserted wherever two or more network elements met, and route decisions were modelled based on the assumption that when faced with any footpath-based junction, a decision must be made by an individual to either continue in the same direction, return the way they came, or to select one of the other available elements open to them. In the case of a footpath meeting a road, it was assumed that one choice would be to cross the road taking the shortest route to intersect a footpath on the other side of the road. No formal pedestrian crossings were mapped due to incomplete data, but it is assumed that most of these coincided with the mapping strategy described above. The different resolution of the road- and footpath-based networks is shown graphically in Figures 1 and 2 respectively. Once the walkability indices were calculated, quartiles were calculated for each of the continuous indices for road- and footpath-based walkability for both the 5- and 10-minute buffers in order to provide a 4-category variable (low [1], low-medium [2], medium-high [3], high [4]) for each.

Component information for calculation of the walkability indices was unavailable for 182 (15.1%) households/respondents meaning that data for these respondents were excluded from subsequent inferential analyses. Examination of the distribution of the sociodemographic and health characteristics of these respondents (as captured in the present study – see covariates in Section 2.2.4) in comparison to the remainder of the sample indicated no significant differences. Of the two indicators of socioeconomic status (i.e., housing tenure and economic strain – see covariates in Section 2.2.4), there was a significantly higher proportion of homeowners in the group who were excluded (79% in the excluded group vs 69% in the analytic group, $p<0.05$), but no significant difference between the excluded group and the analytic group in economic strain.

< INSERT FIGURES 1 AND 2 HERE >

2.2.3 Other covariates

All regression models were adjusted for a number of sociodemographic, socioeconomic, and health variables. Sociodemographic variables included gender (male [0], female [1]) and age (categorical for descriptive analyses: 16-29 [0], 30-44 [1], 45-59 [2], 60-74 [3], 75+ [4]; continuous for inferential analyses; missing data for 17 respondents [1.4%]). Socioeconomic variables included tenure (house owner [0], tenant [1]; missing data for 11 respondents [0.9%]) and economic strain (single-item self-report measure of how the respondent copes financially: comfortable [1], can manage [2], have to be careful [3], strained [4]; missing data for 4 respondents [0.3%]). Health variables included having a long-term illness (no [0], yes [1]) and body mass index (BMI; categorical for descriptive analyses: underweight/normal [0], overweight [1], obese [2]; continuous for inferential analyses; missing data for 67 respondents [5.5%]). Models were also adjusted for whether the respondent owns a bicycle (yes [1], no [0]; missing data for 1 respondent [<0.1%]) and the number of cars available to the household (categorical for descriptive analyses: none [0], 1 or more [1]; continuous for inferential analyses: from 0 onwards). Reasons for adjustment for bicycle ownership were as follows: use of a bicycle may act as a facilitator to active travel, just as car ownership may act as an inhibitor; however, bicycle users may make use of either road or footpath networks (or both), and as such, use of a bicycle may influence the relationship between road- and/or footpath-based indices of walkability and active travel. Finally, as data were collected throughout the calendar year, regression models were adjusted for season (spring [1], summer [2], autumn [3], winter [4]) as the seasonal effects of weather may influence active travel (Tucker and Gilliland, 2007).

2.3 Ethics

The PARC study was reviewed and granted ethical approval by the Office for Research Ethics Committees Northern Ireland (ORECNI) (Reference number: 09/NIR02/66). All aspects of the project were carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for research involving humans, and all respondents provided written consent before taking part in the study.

2.4 Analytic strategy

Weighted frequency and cross-tabulation analyses were initially conducted to examine the distribution of active travel by walkability and by the sociodemographic and socioeconomic characteristics of the sample. Two Wilcoxon signed-rank sum tests were conducted (walkability was non-normally distributed) in order to examine differences between the road- and footpath-based walkability indices in the 5-minute buffer zones and the 10-minute buffer zones.

This was followed by a series of crude and fully adjusted zero-inflated negative binomial (ZINB) regression models examining the effects of road- and footpath-based walkability (in the 5- and 10-minute buffer zones) on active travel. ZINB regression analysis was selected as the most appropriate analytic technique as the dependent variable (active travel) included a large proportion of zero count data (i.e., respondents whose GPAQ score indicated no active travel) and was over-dispersed (i.e., the variance of the dependent variable exceeded the mean) (Afifi et al., 2007; Cheung, 2002; Long and Freese, 2003; Zaninotto and Falaschetti, 2011). Furthermore, nested comparisons with zero-inflated Poisson models (ZIP) using the Likelihood Ratio test (Long and Freese, 2003), and non-nested comparisons with negative binomial models using the Vuong test (Vuong, 1989) indicated that the ZINB provided the best fit for the data given the distribution of the dependent variable. ZINB regression analysis comprises two stages: i) the dependent variable is regressed (using Poisson regression with robust standard errors; Cameron and Trivedi, 2009) onto the primary covariate and any other covariates that are included for the purpose of adjustment in order to examine associations between the levels of the dependent variable (in this case, the number of minutes of active travel per week) and levels of the primary covariate (walkability); ii) the analysis derives a latent binary variable (respondents who never have excess zero counts vs respondents who may have excess zero counts) and runs a logit model using the same covariates as those selected for the first stage (or whichever covariates are deemed relevant) in order to examine the odds of being in the 'excess zeros' active travel group based on levels of walkability. All analyses were conducted in Stata12 (StataCorp, 2011).

3.0 Results

3.1 Sample characteristics

The sample comprised 1209 respondents aged 16-94 (mean: 50.4; SD: 18.9; 17 did not provide age), of whom 719 (59.5%) were female. Less than one-third of the sample (31.0%) reported a long-term illness, but more than half (56.2%) were in the overweight/obese BMI category (see Table 1). Nearly two-thirds of the sample were homeowners (70.5%), and more than half (51.0%) reported being economically able to manage/being comfortable. Two-thirds of the sample reported having a bicycle (66.7%) and three-quarters (75.1%) reported owning at least one car (see Table 1).

< INSERT TABLE 1 HERE >

3.2 Active travel

The range of values for average number of minutes of active travel per week was 0-3360, with a median of 80 (25% lower bound=0; 75% upper bound=240). There were 473 (39.2% unweighted; 37.8% weighted for gender and age; 37.7% weighted for gender, age, and season) respondents who reported zero active travel in the previous seven days.

3.3 Walkability

Prior to calculating quartiles for the road- and footpath-based walkability indices in the 5- and 10-minute buffers, descriptive statistics and inferential statistical tests were conducted in order to examine the distribution of, and differences between road- and footpath-based measures of walkability (see Table 2). Results of Wilcoxon signed-rank sum tests indicated significant differences between the road- and footpath-based walkability indices in both the 5- minute (Z=-2.414, $p<0.05$) and 10-minute (Z=-2.499, $p<0.05$) network buffer zones (see Table 2).

< INSERT TABLE 2 HERE >

3.4 Zero-inflated negative binomial regressions (ZINB)

Results of the first stage of the crude ZINB analysis (i.e., analysis of count data) indicated a gradient of increasing levels of active travel with increasing levels of walkability (e.g., (exp)B=1.05 (SE=0.12) for those in the low-medium road-based walkability area in the 5-minute buffer compared to (exp)B=1.51 (SE=0.13) for those in the high road-based walkability area; see Table 3). This gradient was evident for the road- and footpath-based walkability indices in both the 5- and 10-minute buffer zones, and although the effects attenuated somewhat in the fully adjusted model (e.g., (exp)B=1.05 (SE=0.22), (exp)B=1.15 (SE=0.11), (exp)B=1.22 (SE=0.12) for the low-medium, medium-high, and high road-based walkability areas respectively), a gradient was still evident, with stronger effects for the 10-minute buffer zone (see Table 3 and online supplementary Table S1).

Results of the second stage of the crude ZINB analysis (i.e., analysis of active travel as a latent binary variable) did not show the same pattern of gradients for increasing levels of walkability in the road-based 5-minute buffer. For example, respondents living in the low-medium walkability area based on road-based walkability were 38% ((exp)B=0.62 (SE=0.18) less likely to be in the 'zero physical activity' group than in the 'non-zero physical activity' group than respondents living in the low walkability area, compared to 20% ((exp)B=0.80 (SE=0.18) when walkability was calculated using path-based indices (see Table 3). This pattern of results was also evident in the adjusted model. For example, those in the low-medium walkability area based on road-based walkability in the adjusted model were 44% ((exp)B=0.56 (SE=0.20) less likely to be in the 'zero physical activity' group than in the 'non-zero physical activity' group than respondents living in the low walkability area, compared to 27% ((exp)B=0.73 (SE=0.20) when walkability was calculated using path-based indices (see Table 3). However, such differences were less evident in the estimates from crude and adjusted models using the 10-minute buffer, with road- and path-based estimates being very similar, and demonstrating the expected gradients of decreased likelihood of being in the ‘zero physical activity’ group as levels of walkability increased (see Table 3 and online supplementary Table S1).

< INSERT TABLE 3 HERE >

3.5 Comparison of model fit

Examination of the Wald $\chi 2$, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) model fit statistics for the crude and adjusted models using road- and footpath-based walkability in the 5-minute buffer zone indicated that road-based walkability provided a better model fit (see Table 3). However, comparison of the exponentiated beta coefficients for the road- and footpath-based models in the 5-minute buffer zone were virtually identical. Examination of the fit statistics for the crude and adjusted models using road- and footpath-based walkability in the 10-minute buffer zone also indicated a better fit for the road-based model, though the differences here between the fit statistics for the road- and footpath-based walkability were marginal, and once again, the exponentiated beta coefficients of the two models were comparable (see Table 3).

3.6 Sensitivity analyses

We ran a series of sensitivity analyses in order to establish if footpath-based intersection density provided a better fit to the model than the full footpath-based walkability index, and also if footpath-based intersection density provided a better fit than road-based intersection density. Results indicated that whilst both road- and footpath-based intersection density captured variance in active travel more effectively than the full walkability index (as would be expected from the findings of previous research, e.g., Leslie et al., 2007, Ellis et al., 2016), there was little difference in results regardless of whether road- or path-based intersection density measures were used (results available on request).

Additionally, in order to adjust for the possibility that bicycle and car ownership were acting as moderators, we re-ran the models including interaction terms (bicycle ownership x walkability/intersection density; car ownership x walkability/intersection density) (results available on request). However, although inclusion of the interaction terms attenuated their direct effects on active travel, the interaction terms themselves were not significant, and the overall pattern of results did not differ from the models without interaction terms.

4.0 Discussion and Conclusions

The aim of the present study was to compare the utility of road- versus footpath-based walkability indices and their associations with active travel among a cross-sectional sample of adults in an urban conurbation in Northern Ireland, UK. Results of Wilcoxon signed-rank sum tests (unadjusted analyses) suggested there were significant differences between road- and footpath-based measures of walkability for both buffer zones. However, in the regression analyses the two measures performed comparably as regards their associations with active travel, with only marginal differences in model fit.

Previous road-based walkability measures have proved useful in determining the association between neighbourhood characteristics and physical activity (Grasser et al., 2013). However, they do have their drawbacks: we have demonstrated that a road-based network may not accurately capture the available space for physical activity due to errors in the classification of roads (Figure 1) or failure to capture pedestrian infrastructure that does not run parallel to the road, such as footbridges and footpaths in parks. This may be particularly relevant for areas with greater access to green space, which may subsequently have more infrastructure that supports walking. It has been recognised that there is a need to account for these possible errors in order to improve assessment of environmental support for physical activity such as access to public open space for physical activity (Koohsari et al., 2015; Schipperijn, Stigsdotter, Randrup, & Troelsen, 2010).

In addition, using road-networks ignores the fact that some routes are unsuitable (e.g., motorways) or undesirable for walking and physical activity. Therefore, in certain circumstances roads may be of limited value for non-motorised users. In a stated preference survey, respondents indicated that they would be willing to cycle up to twenty minutes longer in order to switch from cycling on the road to an off-road bicycle trail as part of their journey (Tilahun, Levinson, & Krizek, 2007). This indicates that road-networks may not be accurately capturing the potential influence an environment may exert on choices to be physically active.

Finally, given that both road- and footpath-based measures of walkability were similar, our data suggests that footpath-based walkability measures may be useful when the use of road-based walkability is not appropriate. For example, footpath-based walkability could be used to further explore how wider neighbourhood design might influence the findings of non-road-based environmental interventions, such as urban greenways (New South Wales Health Department, 2002), in addition to the impact of interventions to improve pedestrian connectivity, such as the addition of urban trails (Fitzhugh, Bassett, and Evans, 2010). Given the emphasis that the World Health Organisation (WHO, 2016) have placed on the need for access to urban greenspace to improve public health, improving methods to evaluate the influence of changes in green space on health and health-related behaviours remains a priority, and the proposed footpath-based walkability measures may be useful in that context.

The present study has a number of strengths: it utilised a large, representative sample, across a wide (adult) age span; active travel was measured using a reliable and well-validated measure (i.e., the GPAQ); the study utilised two objective measures of the built environment, both road- and footpath-based indices of walkability, an approach which has been adopted as a protocol by the International Physical Activity and the Environment Network (IPEN) (Adams et al., 2014), and the design of the study and large sample size allowed for the adjustment of a range of sociodemographic and socioeconomic variables when modelling the effect of walkability on active travel.

The limitations of the present study were: the subjective assessment of active travel (compared to more objective measures such as accelerometers); the data were cross-sectional; and the study was restricted to one area of Belfast that is known to be socially and economically deprived. It would be important to assess the generalisability of the findings by examining a greater distribution of urban forms and a broader spectrum of the population. It is also noted that in basing the connectivity measure on intersection density, results will differ according to the assumptions made in mapping intersections. For example, different studies (Ellis et al., 2016; Tal and Handy, 2012) have adopted alternative approaches for defining intersections of footpaths, particularly when they cross highways, while also being influenced by the specific type of street network design (Marshall et al., 2014).

In conclusion, results of the study suggest that road- and footpath-based walkability networks are comparable in their associations with active travel, and therefore could be used in future studies where road-based network data is not available. Given the call for built environment interventions (Hunter et al., 2015), such a model has important implications for assessing non-road-based environmental change interventions.

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Conflicts of interest

None declared.

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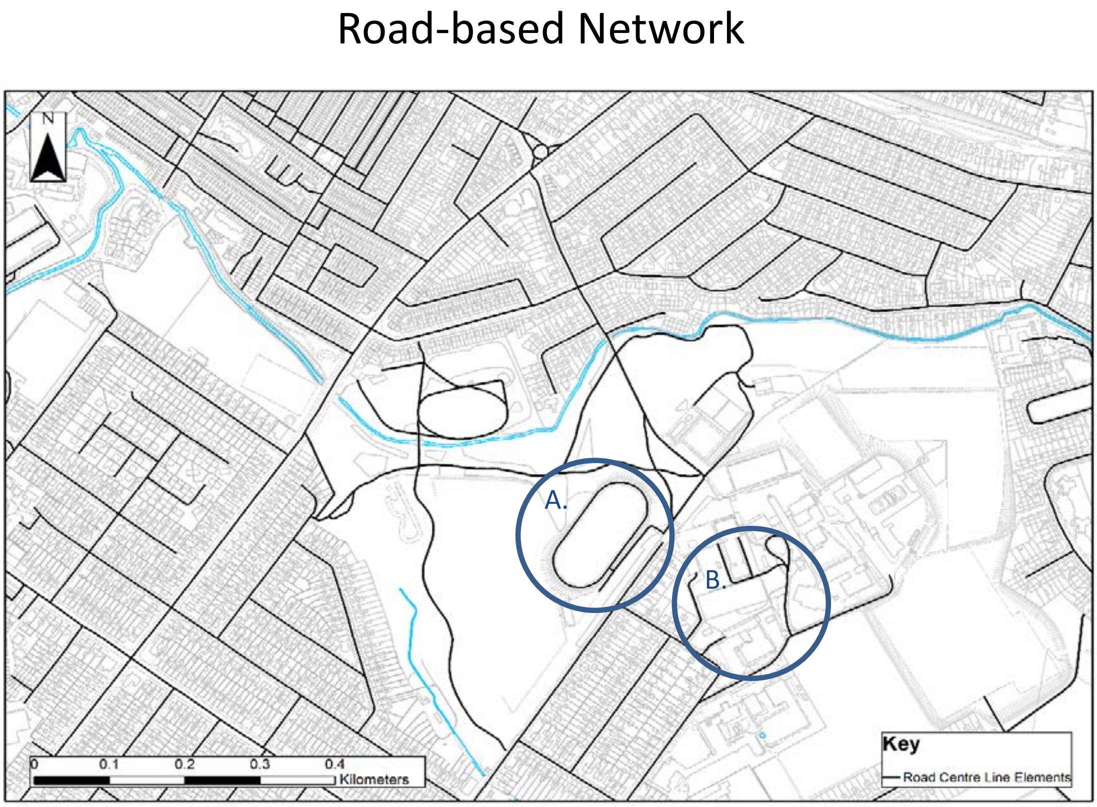
Figure 1



Note: The illustration above shows the relative resolution of the road network compared to the footpath network (see Fig. 2), while also highlighting some of the issues of ambiguity and potential errors that can arise when using road networks, with the bottom right quadrant showing an oval cycling track (A) as a digitised road and private roads around a school (B) included incorrectly in the road network.

Figure 1 Visual resolution of the road-based network in the Belfast case study

Figure 2

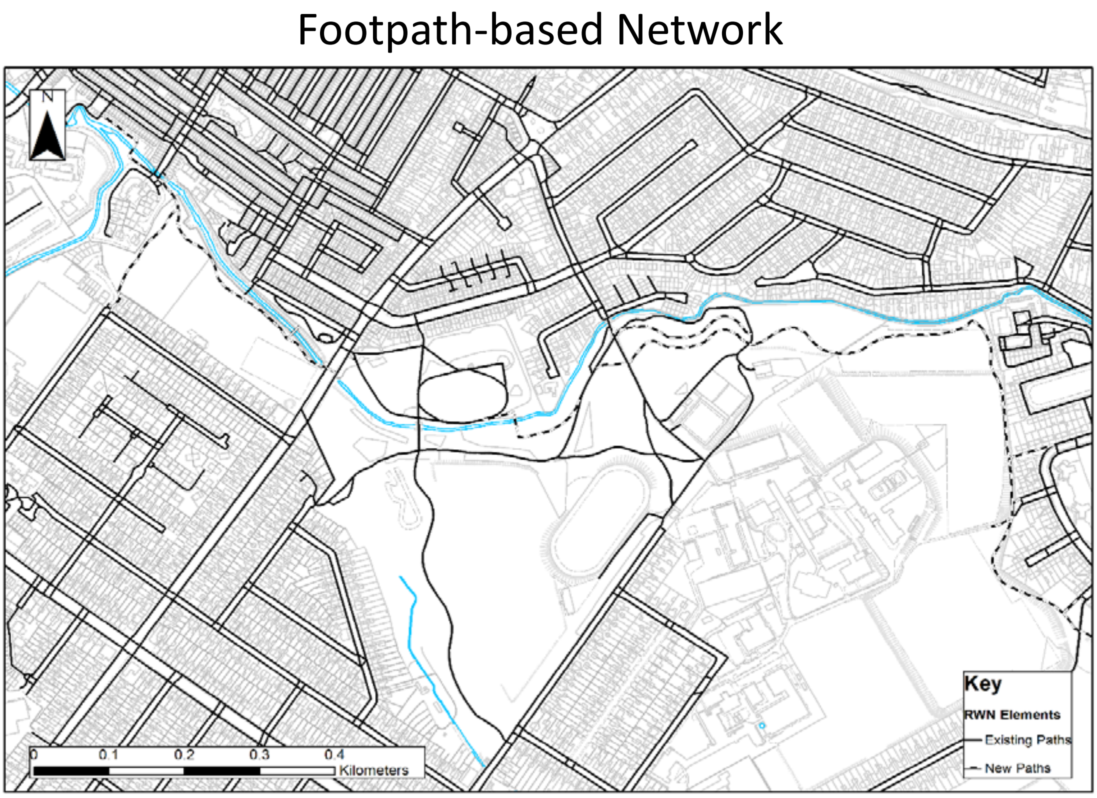


Figure 2 Visual resolution of the footpath-based network in the Belfast case study

TABLES

Table 1 Distribution of respondents by active travel, walkability, sociodemographic, health, and socioeconomic characteristics, and other covariates

			N (%)
Active travel		None	473 (39.2)
		Some	735 (60.8)
Built environment	Walkability	Low	257 (25.0)
		Low-medium	257 (25.0)
		Medium-high	257 (25.0)
		High	256 (25.0)
Sociodemographic characteristics	Gender	Male	490 (40.5)
		Female	719 (59.5)
	Age group	16-29	191 (16.0)
		30-44	320 (26.9)
		45-59	279 (23.4)
		60-74	240 (20.1)
		75+	162 (13.6)
Health characteristics	Long-term illness (LTI)	No	834 (69.0)
		Yes	375 (31.0)
	Body mass index (BMI)	Underweight	18 (1.6)
		Normal	482 (42.2)
		Overweight	412 (36.1)
		Obese	230 (20.1)

Socioeconomic characteristics	House tenure	Owner	845 (70.5)
		Tenant	353 (29.5)
	Economic strain	Comfortable	168 (13.9)
		Can manage	447 (37.1)
		Need to be careful	495 (41.1)
		Strained	95 (7.9)
Other covariates	Has a bicycle	No	402 (33.3)
		Yes	806 (66.7)
	Number of cars	None	301 (24.9)
		At least 1	908 (75.1)
	Season	Spring	236 (19.5)
		Summer	241 (19.9)
		Autumn	298 (24.7)
		Winter	434 (35.9)

Table 2 Descriptive statistics for road- and footpath-based walkability indices in the 5- and 10-minute buffer zones, and results of Wilcoxon signed-rank sum test

	Descriptives		Wilcoxon signed-rank sum test	
	Range	**Median (25% lower bound-75% upper bound)**	***Z***	***p***
Road-based; 5-minute buffer	-7.15 – 8.80	0.74 (-2.81-2.75)		
Footpath-based; 5-minute buffer	-6.61 – 8.36	0.78 (-2.90-2.68)	-2.414	0.016
Road-based; 10-minute buffer	-9.14 – 8.00	-0.03 (-3.20-3.20)		
Footpath-based; 10-minute buffer	-8.70 – 7.58	0.01 (-3.26-3.05)	-2.499	0.013

Table 3 Results and fit statistics of crude and fully adjusted zero-inflated negative binomial regression models examining associations between road- and footpath-based indices of walkability and active travel in the 5- and 10-minute buffers

			5-minute buffer		10-minute buffer	
			RBW	PBW	RBW	PBW
			B (SE)	B (SE)	B (SE)	B (SE)
Crude	Count	Walkability (low is ref)				
		Low-medium	1.05 (0.12)	1.05 (0.12)	1.14 (0.12)	1.13 (0.12)
		Medium-high	1.23 (0.12)	1.21 (0.12)	1.29 (0.11)*	1.32 (0.11)*
		High	1.51 (0.13)***	1.51 (0.13)***	1.76 (0.12)***	1.75 (0.12)***
	Inflate	Walkability (low is ref)				
		Low-medium	0.62 (0.18)**	0.80 (0.18)	0.74 (0.18)	0.80 (0.18)
		Medium-high	0.76 (0.18)	0.67 (0.18)*	0.66 (0.18)*	0.68 (0.18)*
		High	0.61 (0.18)**	0.66 (0.18)*	0.60 (0.18)**	0.61 (0.18)**
	Fit statistics	*Wald χ2 (df3)*	*15.30*	*14.80*	*26.93*	*26.38*
		AIC	*9881.88*	*9885.02*	*9865.37*	*9866.89*
		BIC	*9926.29*	*9929.43*	*9909.78*	*9911.30*
Fully adj§	Count	Walkability (low is ref)				
		Low-medium	1.05 (0.11)	1.04 (0.11)	1.08 (0.11)	1.07 (0.11)
		Medium-high	1.15 (0.11)	1.15 (0.11)	1.15 (0.11)	1.18 (0.11)
		High	1.22 (0.12)	1.20 (0.12)	1.37 (0.12)**	1.35 (0.12)*
	Inflate	Walkability (low is ref)				
		Low-medium	0.56 (0.20)**	0.73 (0.20)	0.64 (0.20)*	0.69 (0.20)
		Medium-high	0.80 (0.20)	0.72 (0.21)	0.70 (0.21)	0.70 (0.21)
		High	0.73 (0.22)	0.78 (0.22)	0.72 (0.23)	0.73 (0.23)
	Fit statistics	*Wald χ2 (df12)*	*63.47*	*63.00*	*69.37*	*69.32*
		AIC	*8979.40*	*8985.15*	*8977.30*	*8979.58*
		BIC	*9110.52*	*9116.28*	*9108.42*	*9110.70*

RBW: road-based walkability; PBW: footpath-based walkability; B: exponentiated beta coefficient; SE: standard error [robust]; AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion; **p*<0.05, ***p*<0.01, ****p*≤0.001; χ2: chi square; df: degrees of freedom; [§]Model adjusted for: gender, age, long-term illness (LTI), body mass index (BMI), housing tenure, economic strain, bike ownership, car ownership, and season

ONLINE ONLY SUPPLEMENTARY TABLE

Table S1 Results of fully adjusted zero-inflated negative binomial regression models showing the effects of road- and footpath-based walkability in the 5- and 10-minute buffer zones on average minutes per week of active travel

		5-minute buffer		10-minute buffer	
		RBW	PBW	RBW	PBW
		B (SE)	B (SE)	B (SE)	B (SE)
Count model	Walkability (low is reference)				
	Low-medium	1.05 (0.11)	1.04 (0.11)	1.08 (0.11)	1.07 (0.11)
	Medium-high	1.15 (0.11)	1.15 (0.11)	1.15 (0.11)	1.18 (0.11)
	High	1.22 (0.12)	1.20 (0.12)	1.37 (0.12)**	1.35 (0.12)*
	Covariates				
	Gender	0.94 (0.08)	0.95 (0.08)	0.95 (0.08)	0.95 (0.08)
	Age	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
	Long-term illness	0.79 (0.09)*	0.79 (0.09)*	0.79 (0.09)**	0.78 (0.09)**
	Body mass index	0.99 (0.01)*	0.99 (0.01)*	0.99 (0.01)*	0.99 (0.01)*
	Housing tenure	1.23 (0.10)*	1.24 (0.10)*	1.20 (0.10)	1.20 (0.10)
	Economic strain	1.10 (0.05)*	1.10 (0.05)*	1.09 (0.05)	1.09 (0.05)
	Owns a bicycle	1.13 (0.09)	1.13 (0.09)	1.13 (0.09)	1.13 (0.09)
	Car ownership	0.89 (0.05)*	0.89 (0.05)*	0.90 (0.05)*	0.90 (0.05)*
	Season	0.95 (0.03)	0.95 (0.04)	0.96 (0.04)	0.96 (0.04)
Inflate model	Walkability (low is reference)				
	Low-medium	0.56 (0.20)**	0.73 (0.20)	0.64 (0.20)*	0.69 (0.20)
	Medium-high	0.80 (0.20)	0.72 (0.21)	0.70 (0.21)	0.70 (0.21)
	High	0.73 (0.22)	0.78 (0.22)	0.72 (0.23)	0.73 (0.23)
	Covariates				
	Gender	1.04 (0.15)	1.05 (0.15)	1.04 (0.15)	1.05 (0.15)
	Age	1.01 (0.00)*	1.01 (0.00)*	1.01 (0.00)*	1.01 (0.00)*

Long-term illness	2.50 (0.16)***	2.51 (0.16)***	2.56 (0.16)***	2.54 (0.16)***
Body mass index	1.02 (0.01)	1.02 (0.01)	1.02 (0.01)	1.02 (0.01)
Housing tenure	1.01 (0.19)	1.03 (0.19)	1.03 (0.19)	1.03 (0.19)
Economic strain	0.97 (0.09)	0.98 (0.09)	0.98 (0.09)	0.98 (0.09)
Owns a bicycle	0.56 (0.18)***	0.56 (0.18)***	0.54 (0.18)***	0.54 (0.18)***
Car ownership	1.73 (0.10)***	1.71 (0.10)***	1.69 (0.10)***	1.69 (0.10)***
Season	0.99 (0.07)	0.98 (0.07)	0.97 (0.07)	0.96 (0.07)

RBW: road-based walkability; PBW: footpath-based walkability; B: exponentiated beta coefficient; SE: standard error [robust]; *p<0.05, **p≤0.01, ***p≤0.001